# AMUSING EXPERIMENTS

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**(after Martin Gardner)**

SCIENCE READER
FOR THE EIGHTH FORM
OF SECONDARY SCHOOL

●

*Adapted*
**by M. Stoliar and L. Fomin**

Third Edition

## DEAR FRIENDS!

In this book you will find descriptions of amusing experiments, which are based upon well-known scientific facts. You can easily carry out these experiments yourselves, and you will not need any special equipment. But if you wish to show the experiments to your friends, we advise you to practise them a few times before you demonstrate.

The experiments are not only amusing: after you have carried out each experiment and read the explanation, you will learn something interesting and important in such fields of science as mathematics, physics, chemistry, biology, astronomy and psychology.

The book will help you to learn a number of new English words which are connected with science. When you have learned them, it will be much easier for you to read scientific literature in English in the senior forms.

At the end of the book you will find the vocabulary of the words which you may not know. Some of the terms are given in the footnotes.

We hope that you will find the book interesting and easy to read, and that it will help you to become science-minded people.

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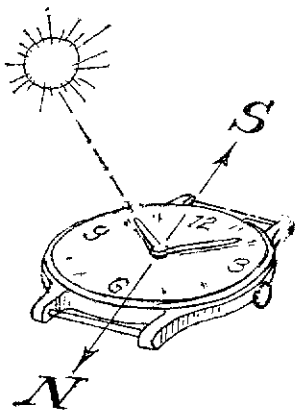
## ASTRONOMY

### YOUR WATCH BECOMES A COMPASS

Do you know that you can use your watch as a compass on a sunny day? Look at the watch which is on your hand and point the hour-hand [1] in the direction of the sun, as you see in the picture. Imagine a line which runs from the centre of the watch through a point half-way between [2] the hour-hand and number one. This line will point south.[3]

If you know astronomy a little, you will understand why this works. In the northern half of the earth, the sun is in the south at noon. In our country the real noon is one o'clock.[4] If at that time we point the hour-hand at the sun, the hour-hand and number one will point south. That is why you must imagine a line which will run from the centre of the watch through a point half-way between the hour-hand and number one. It will point south.

If you are in the southern part of our planet, you must point number 12 at the sun. (The angle between this number




[1] **point the hour-hand** — направьте часовую стрелку

[2] **through a point half-way between** — через точку, находящуюся на равном расстоянии между

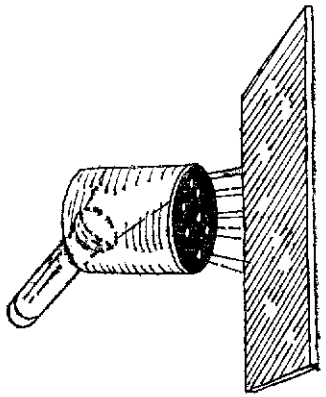
[3] **to point south** — указывать на юг

[4] **the real noon is one o'clock** — в действительности полдень наступает в час дня *(На территории СССР введено декретное время, переведенное на час вперед, с целью более рационального использования населением дневного света в течение суток.)*

and the hour-hand will then show north.) The line which you can imagine between number twelve and the hour-hand will then show north.

### A PLANETARIUM OUT OF A CYLINDRICAL BOX

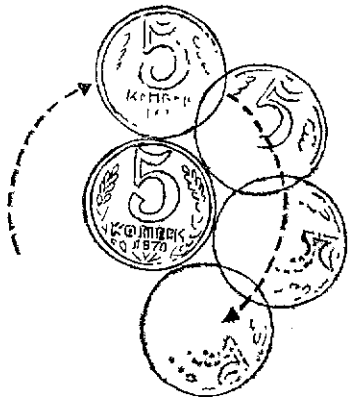
You can make a planetarium with the help of a cylindrical cardboard box.[1] The box will show beautiful pictures of stars on the wall. You can take a book on astronomy and copy the group of stars which you want to study on a sheet of paper. Then you must put your picture face down on the outside bottom of the box.[2] Then you take a nail and make holes through the box at each mark. You can do that because you see the marks of stars through the paper. The holes will make a picture of the group of stars as you will see it in the mirror, but the picture will be right when it is on the wall.



Now you may open your *planetarium*. You take your box into a dark room and put an electric torch [3] into the open end. It is better when the torch shines on the side of the box and not directly on the holes. Then you will get a large picture of the group of stars on the wall. If you want, you may turn the box to study the group of stars from different positions.

### AN EXPERIMENT WITH A COIN

How many times does the earth rotate during one trip round the sun? If we want to answer this question, we must first know from what place we are looking. As seen[4] from the sun, the earth makes $365^1/_4$ turns. But as seen from a star (which is, as you know, very, very far away), the earth rotates $366^1/_4$ times. So the day as seen from the star is a little shorter than the day as seen from the sun.



You can explain this with the help of the following simple experiment. Put two five-kopek coins [1] on your table. They must touch each other, as shown in the picture. You hold the lower coin with your left finger and rotate the other coin round it. The two coins must always touch each other. Now, how many turns has the coin made when it comes back to the place where it began its trip? The answer will surprise you. It is not one, but two. As seen from the central coin, the other coin rotates only once, but you are far away. That is why you see two turns.

[1] a cardboard box — коробочка из картона
[2] face down on the outside bottom of the box — лицевой стороной на наружную часть дна коробки
[3] an electric torch — электрический фонарик
[4] As seen — *эд.* Как было бы видно

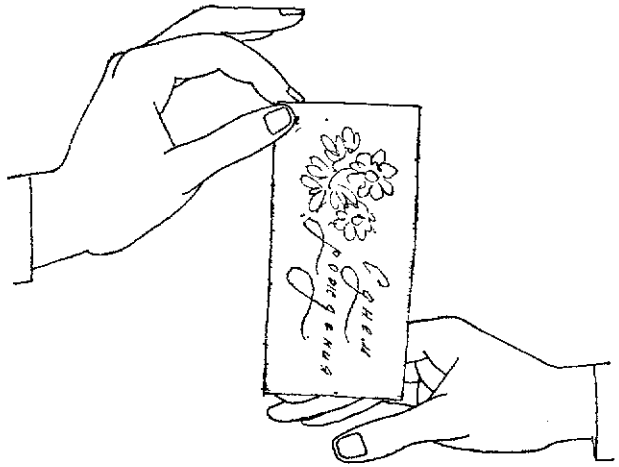
[1] a five-kopek coin — пятикопеечная монета

## BIOLOGY

### CATCH THE POSTCARD

Hold a postcard in your left hand, as you see in the picture; your right hand is ready to catch the postcard, but the fingers are not touching it. If you let the postcard go,[1] you'll find it easy to catch it with your right hand before it falls down.

Now see if your classmate can catch the postcard when you let it go. Let him hold his fingers on each side of the postcard, as you did before. Let the postcard go. His fingers will not catch it. You can repeat this as often as you want. He will not catch the postcard.

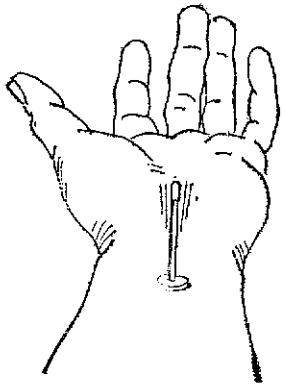


[1] **If you let the postcard go** — Если вы отпустите (почтовую) открытку



You can catch the postcard because your brain can send "let it go" and "catch" signals [1] to your two hands at the same moment. But when you hold the postcard for your classmate to catch, his brain must first see that the postcard is falling, then send a "catch" signal to his fingers. This takes more time. That is why your friend cannot catch it.

### PULSE DETECTOR[2]



There are many machines which cost hundreds of roubles that show the beating of our hearts. This pulse detector which costs less than a kopek will help you to watch the beating of your heart very well.

Put a thumb-tack into the base of a large match and put it on your hand on the place where you can feel the pulse, when your arm is resting on a table. The head of the match will move a little there and back with each beating of your heart.

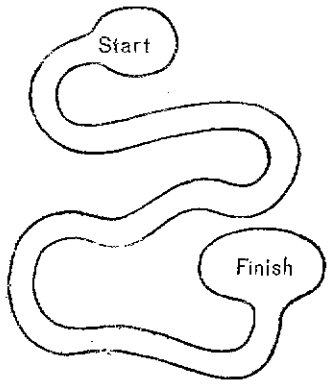
### IT IS VERY DIFFICULT TO LEARN TO WRITE

Now, when you have learned to write and draw pictures, you may think that it is very easy to do all that. But it is very difficult for a little child. He has not yet built up all the reflexes that could tell him how to move his hand to draw or write correctly.

If you want to feel like a child and understand his problem, the problem how to make his hand and eyes work together, here is an interesting way to do that.

Put this page on your table and put a mirror in front of the picture. Now raise your left hand and hold it over the picture in such a way that you cannot see it; you can only see its reflection in the mirror. Take a pencil in your right hand and put it at the place START. Now look only in the mirror and try to draw a line from START to FINISH, but you mustn't go

[1] **"let it go" and "catch" signals** — сигналы «отпусти» и «лови»
[2] **Pulse Detector** — Измеритель частоты биения пульса



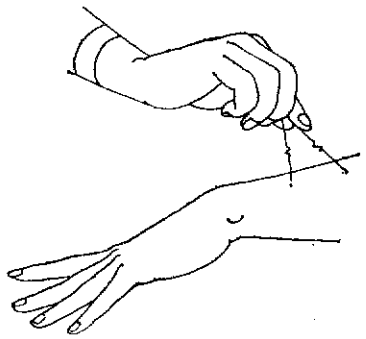

over the borders.[1] It isn't easy because your reflexes don't work so well when you see a reversed image.[2] So now you will understand that it is very difficult for a child when he begins to learn to write or draw pictures. You have felt it like a child.

### ONE OR TWO POINTS?

Take a hairpin and open its points until they are four centimetres away from each other. Ask your friend to close his eyes and tell you if you are pressing one or two points of the hairpin against his arm. He will find with surprise that he can't tell you that correctly. When you are pressing two points, he will feel them as one point.

Now close the hairpin until its points are only two millimetres away from each other. Put the points on your friend's finger-tips[3] and ask him the same question. Now he will be right. He will tell you correctly if you are pressing one or two points of the hairpin against his finger-tips.

This simple experiment shows that different parts of the body feel the points of pressure[4] in a different way. You can, if you want, find out which parts of the body feel the points of pressure better and which feel them worse.



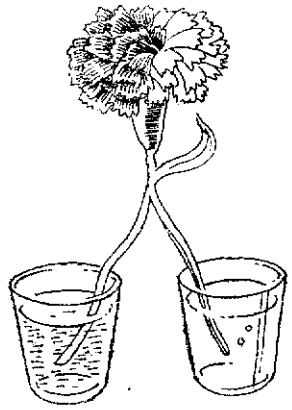
[1] **to go over the borders** — заходить за линии (границы)

[2] **a reversed image** — зеркальное изображение

[3] **finger-tips** — кончики пальцев

[4] **the points of pressure** — точки прикосновения

### A FLOWER OF TWO COLOURS



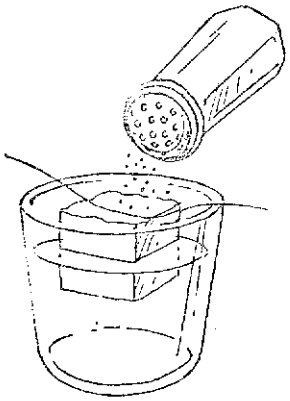
When flowers grow, water from the earth goes up through the roots and stem and into the flowers and leaves. It is easy to demonstrate the process by the following experiment. You fill two glasses with water. Then colour the water in one glass red with the help of some food colouring.[1] Now carefully divide the stem of a beautiful white flower into two parts. Put half the stem in one glass, the other half in the other glass, as you see in the picture. After a few hours you will find that one side of the flower has become red. You may be sure that everybody will look at your flower of two colours with surprise.

[1] **colour the water in one glass red with the help of some food colouring** — подкрасьте воду в одном стакане в красный цвет с помощью какого-либо пищевого красителя

## CHEMISTRY

### AN EXPERIMENT WITH AN ICE CUBE[1]

Put an ice cube from your refrigerator into a glass of water. You have a piece of string 10 centimetres long. The problem is to take out that piece of ice with the help of the string. But you must not touch the ice with your fingers.



You may ask your friends to try to do that when you are having dinner together. There is a salt-cellar on the table. You must use salt when you carry out this experiment.

First you put the string across the piece of ice, as shown in the picture. Then put some salt on the ice. Salt makes ice melt.[2] The ice round the string will begin to melt. But when it melts, it will lose heat. The cold ice cube will make the salt water freeze again.

After a minute or two you may raise the piece of string and with it you will raise your piece of ice!

This experiment can be very useful to you. If, for example, there is ice near the door of your house, you must use very much salt to melt all the ice. If you don't put enough salt,[3] the water will freeze again.

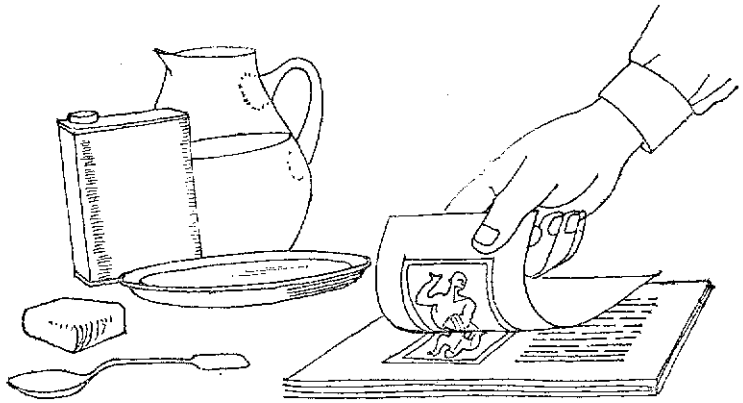
---

[1] an ice cube — кубик льда
[2] Salt makes ice melt.— *зд.* Лед тает от соли.
[3] If you don't put enough salt — Если вы насыплете мало соли



### HOW TO COPY A NEWSPAPER PICTURE

You have often seen interesting and funny pictures in newspapers and you wanted to copy them. How can you do it? Now you will learn how to make a mixture. With the help of



this mixture you can easily copy newspaper pictures on white sheets of paper.

You must mix four parts of water with one part of turpentine. Then you put a very small piece of soap (it must not be larger than half a match-box) and shake the mixture. Soon the soap disappears, but it will not allow the turpentine and water to separate.

Now, if you want to copy a newspaper picture, you must wet it a little with the mixture, then put a white sheet of paper on it and rub the paper strongly with a spoon. The turpentine dissolves enough of the ink and you find a reverse picture on your sheet of paper.

## MATHEMATICS

### THREE DRINKING GLASSES

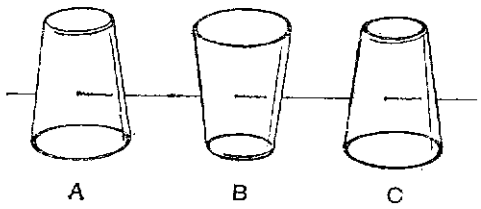
Here is an interesting mathematical trick you can play on your friends. Put three drinking glasses in a row on the table. The glass which is in the centre must stand with its right side up [1] and the two other glasses are standing upside-down. [2] The task is to turn two glasses at a time and to put them all right side up in three moves. [3]

At first you show your friends how to do it. Take glasses *A* and *B*, one in each hand, and turn them over at the same time. Do the same with glasses *A* and *C*, then repeat with *A* and *B*. Now all the three glasses are standing right side up.

Before your friend tries to do the same you turn the central glass upside-down; the two other glasses are standing with their right sides up. Your friend must not notice that you have changed the positions. Then you ask him to put them all right side up in three moves, as you have done it.

He will not notice that the glasses are standing in a different way. You began when two glasses were standing upside-

[1] **right side up** — в обычном положении
[2] **upside-down** — вверх дном
[3] **in three moves** — в три приема

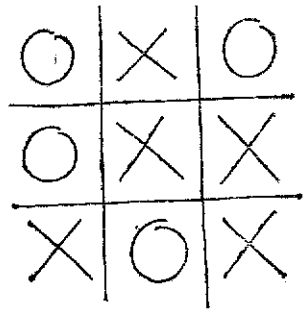





down and one glass right side up; now two are standing right side up and one upside-down. The trick is that from this new position he will not be able to do it. Your friends will try it many times before somebody notices the trick.

### A GAME OF CIRCLES AND CROSSES

Most of you know this mathematical game, of course. You and your friend draw crosses and circles on a sheet of paper. You do it one after another. The first pupil who gets three marks in a row wins. But do you know that you can play this game another way and it will become more interesting? You must try to make your friend win. [1] If you get your three marks in a row, you don't win—you lose!



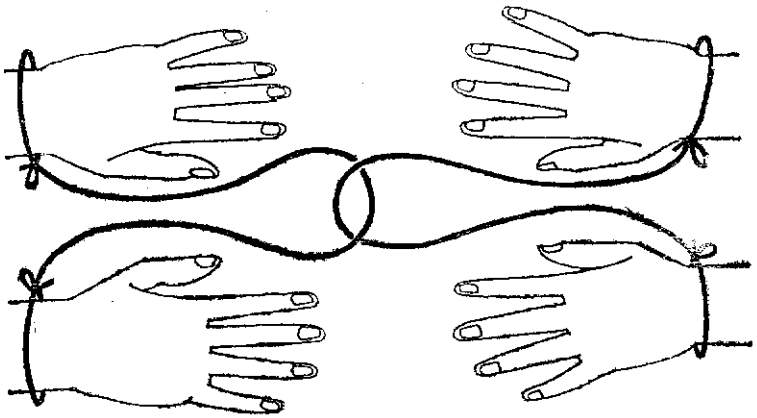
It is more difficult to play this game the other way. The second pupil can always win (if he plays the right way), but he may not win if the first pupil begins with his mark in the centre. Then, if the first pupil always takes a place on the other side of his friend's mark, nobody will win, as in the game which you see in the picture.

If your friend does not know the secret which we have explained, you must play each time so as to leave him the greatest number of ways to win. You may try a few games and you will see how interesting it is to play the game this way.

### TIE THE HANDS OF TWO PEOPLE

Here is an interesting game to show at a birthday party. Divide your friends into pairs. Each pair ties a piece of rope on their hands. The two ropes go round each other, as shown.

[1] **to make your friend win** — сделать так, чтобы ваш друг выиграл



The first pair which separates gets a prize. Of course, they must not cut or untie the rope.

You can separate if you pass the centre of one rope under the rope around your friend's hand, then you must pass the rope over his fingers, then pass the centre back under the rope again.

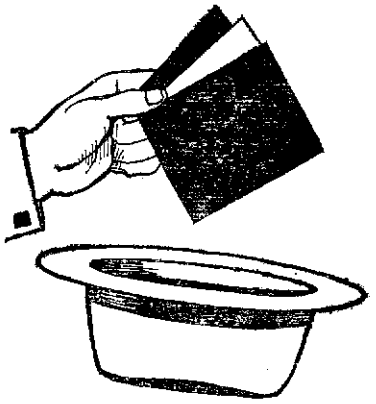
## CAN YOU TIE A KNOT? [1]

Put a piece of rope on the table. Ask anybody to take one end in each hand and tie a knot. Your friend must not let go[2] of any end. It seems impossible, but you can do it easily. The trick is to fold your arms[3] first and then pick up the rope, as shown in the picture. When you unfold your arms, you will find your knot in the centre of the rope.

[1] **to tie a knot** — завязать узел
[2] **to let go** — отпустить
[3] **to fold your arms** — сложить руки



## THE THREE CARDS



In some games you have more chances to win than you think you have. Imagine you have three cards: one is black on two sides (*BB*), one is white on two sides (*WW*), and one is black on one side and white on the other (*BW*). You put them in a hat, then take out a card and put it on the table. What are the chances that the other side will be the same as the upper side?

If the upper side is black, you will perhaps think in the following way: "This can't be the *WW* card. So, it may be the *BB* or the *BW*. The chances are the same."

But the chances are not the same. There are two chances that the other side is black too, and only one chance that the other side is white. There are three possible answers, not two, as you thought. If the upper side is black, it may be that:

1) you see the black side of the *BW* card;
2) it is one of the sides of the *BB*;
3) it is the other side of the *BB*.

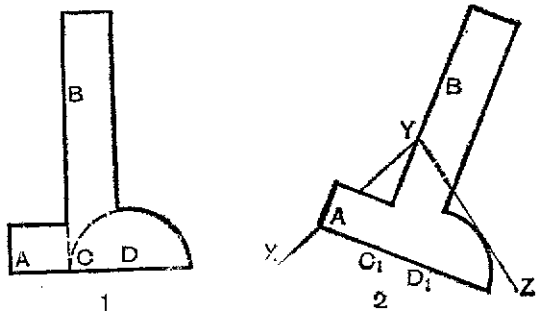
So you see that there are two chances that the other side is black too, and only one chance that it is white.

## CAN YOU TRISECT AN ANGLE? [1]

Two thousand years ago people who studied mathematics tried to trisect an angle with the help of a compass and a ruler. They could not do it. Today you or your teacher of mathematics can prove that it is possible.

You can make a simple instrument which trisects an angle correctly. Here is how you can do it. You cut a piece of cardboard as shown in Picture 1. It is the instrument which you will use to trisect an angle.

[1] **to trisect an angle** — разделить угол на 3 равные части




Put your instrument on the angle $XYZ$ so that point $A$ is on one side of the angle, side $B$ of your instrument goes through point $Y$, and the circle part of the instrument touches the side $YZ$ (Picture 2). Then you make points on the paper at $C$ and $D$ ($C_1D_1$) and draw lines $YC_1$ and $YD_1$. So you have trisected the angle!

If the angle is very acute and you cannot put your instrument on it, you can always make the angle two times larger, trisect it and then divide each angle into two parts. So you have trisected the acute angle.

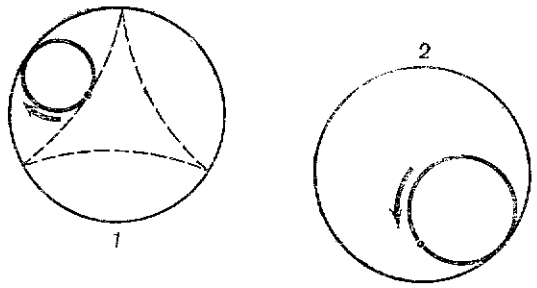
If you know mathematics very well, you will prove why your instrument trisects the angle.

## AN EXPERIMENT WITH TWO CIRCLES

Here is an interesting experiment which you can carry out when you are playing with your friends. Take a piece of cardboard and cut two circles: a large circle and a small one. The small circle must have a diameter one-third that of the large circle. Then put the smaller cardboard circle on the larger circle, mark a point[1] on the smaller circle and roll the circle round the inside rim[2] of the larger circle. On the larger circle you mark the way which your point makes when the smaller circle rolls inside the larger circle. So you will get a triangle of three curved lines, as shown in Picture 1.

[1] mark a point — поставьте точку
[2] the inside rim — внутренний край





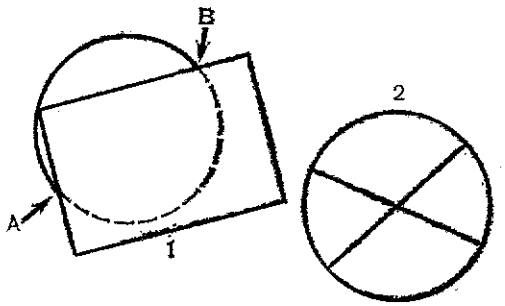

Now ask your friends what figure they will get if the smaller circle has a diameter one-half that of the larger circle (Picture 2). They will give different answers. Then you find out whose answer was right. You cut the third cardboard circle of the size you were discussing and repeat the experiment.

The answer will surprise all of you. The way which the point makes now is the diameter of the larger circle!

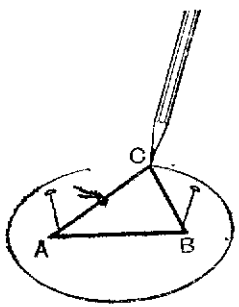
## FIND THE CENTRE OF A CIRCLE

Your teacher of mathematics has taught you how to find the centre of a circle. It takes some time. Here is a simple method.

Put the corner of a sheet of paper on the circumference of the circle (Picture 1), then mark points $A$ and $B$ where the sides of the paper cross the circle. You may be sure that points $A$ and $B$ mark the ends of a diameter. Draw it. Then repeat this process at a different place to get another diameter (Picture 2). You will find the centre where the two lines cross.



## HOW TO DRAW AN ELLIPSE



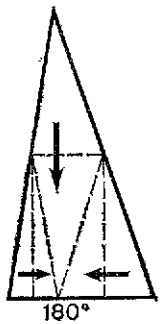

You know that it is easy to draw a circle with a compass. But do you know how to draw an ellipse? Here is an easy way.

You stick two pins in a sheet of paper, then tie a piece of string into a circle and put it over the pins. Next you make the string tight[1] with your pencil, as shown in the picture. You move the pencil round the pins. It will draw a good ellipse.

This method demonstrates the most important fact about an ellipse: the lines which you draw from the two centres to any point on the ellipse always have the same sum. In your ellipse the pins are the centres, and the lines of the strings *AC* and *BC* are the two lines to the same point on the ellipse. As the line *AB* always stays the same, the sum of *AC* and *BC* must always be the same too when your pencil is drawing the ellipse.

If you move the pins nearer together, you will find that the form of your ellipse changes. When the two centres come together, you will have a circle.

## PROVE THAT THE SUM OF ALL THE ANGLES OF A TRIANGLE IS 180°




Do you remember how your teacher of geometry taught you to prove that the sum of all the angles of a triangle is 180°? Yes, of course, you do. But it is interesting to prove it in the following way.

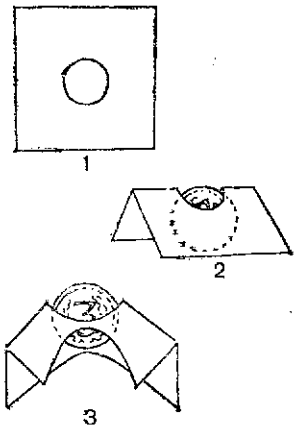
Cut a triangle out of a piece of paper. If you fold over the corners,[2] as shown in the picture, you can easily make the three angles fit together to form a 180° angle at the base of the triangle.

[1] **you make the string tight** — натягиваете веревочку

[2] **If you fold over the corners** — Если вы загнете углы



## YOU CAN PUSH A COIN THROUHG A SMALLER HOLE




Do you know that you can push a coin through a smaller hole? Here is how you can do it. You put a kopek coin[1] on a small piece of paper, then you draw a line round it with a pencil and cut out a hole, as you see in Picture 1. Now the task is to push a three-kopek coin[2] through this hole. You must not tear the paper.

You fold the paper across the hole[3] when a part of the coin is in the hole, as shown in Picture 2. It is now very easy to push the coin through the hole, as you see in Picture 3.

You may use other coins too. For example, you can cut out a hole with the help of a ten-kopek coin and push a twenty-kopek coin through this hole.

The trick always works when the circumference of the hole is a little longer than two diameters of the coin which you want to push through the hole.

## HOW LONG IS THE DIAGONAL OF A SQUARE?

You know that one side of a triangle cannot be longer than the two other sides. But with the help of these four pictures you can prove that the diagonal of a square is as long as its two sides!

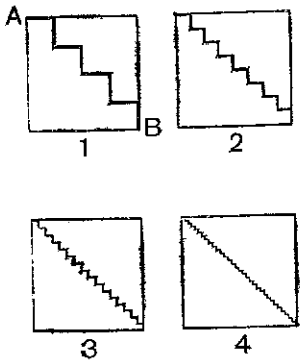
You draw a square 10×10 centimetres. Then you draw a zigzag line[4] from point *A* to point *B*. Each part of the zigzag line is two and a half centimetres long, as shown in Picture 1.

[1] **a kopek coin** — копеечная монета

[2] **a three-kopek coin** — трехкопеечная монета

[3] **You fold the paper across the hole** — Вы складываете бумагу так, чтобы линия сгиба проходила через центр отверстия

[4] **a zigzag line** — зигзагообразная линия




So your zigzag line is 20 centimetres long; it is as long as two sides of the square.

Then you draw the same square again and the zigzag line, as shown in Picture 2. But this time each part of the zigzag line is only two centimetres long. Your line is 20 centimetres long, as it was before.

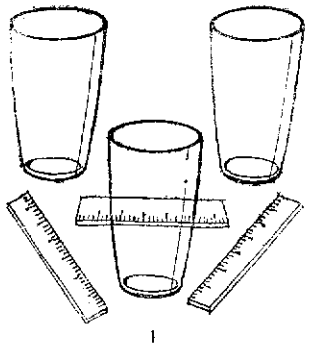
The zigzag line is always 20 centimetres long. The parts of the line become smaller and smaller, as shown in Pictures 3 and 4, but the zigzag line is still 20 centimetres long.

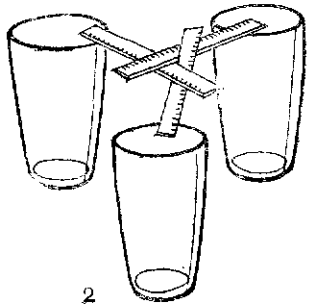
At last the parts become so small that the zigzag line becomes a straight line. But it will be 20 centimetres long!

Now that you have proved it, can you explain the mistake? The explanation is this. The parts of the zigzag line become smaller and smaller, but they never disappear. In other words, the zigzag line will never become a straight line.

## SHORT BRIDGES

Here are three drinking glasses and three rulers. The glasses are standing in such a way that the distance between any two glasses is longer than the ruler (Picture 1). Imagine that each glass is an island and each ruler is a bridge. With the help of these short bridges you must join all the three islands with one another. Of course, you must not move the glasses; they are islands, and you can't move islands! So, can you join them with one another? If you can't, Picture 2 will show you how you can build the bridges.


1


2

## THE PYTHAGOREAN THEOREM[1]

According to the famous Pythagorean theorem the square on the hypotenuse of a right-angled[2] triangle equals the sum of the squares on the other two sides. Here is a very unusual way to prove this theorem.

First draw the squares on the two shorter sides of any right-angled triangle. Divide the square on the larger of these sides into four parts by two lines at right angles to each other and crossing at the centre of the square. One of these lines is parallel to the hypotenuse of the triangle.

Now cut out the small square and the four parts of the larger one. You will find that these five pieces will fit together to form the square on the hypotenuse! Now, when you have done that, can you prove it mathematically?

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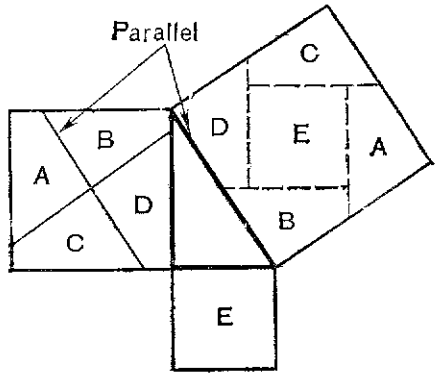
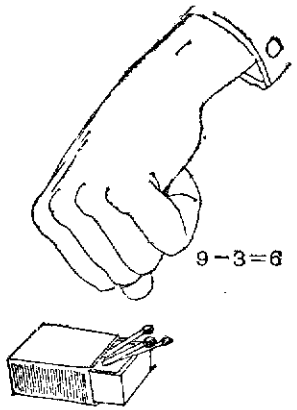
[1] **The Pythagorean Theorem** — Теорема Пифагора
[2] **right-angled** — прямоугольный






## HOW MANY MATCHES ARE THERE IN YOUR HAND?

Take any number you like. For example, you have taken *387*. Now add *3+8+7=18*. Then *387—18=369*. You can divide *369* by *9*. If you take another number and do the same, you will also find that at the end you will be able to divide the number which you get by *9*. This interesting fact will help you to tell how many matches your friend has in his hand. And this is how you can do it.

Put some *21—25* matches in front of him. Then stand far away and don't look at him. Tell him to do the following.

1. He must take any number of matches from *1* to *10* and put them in his bag.

2. Then he must count how many matches there are in front of him and add the two figures of this number. For example: if he counts *16* matches, *1+6=7*. So he must take *7* more matches and put them in his bag.

3. At the end he must take any number of matches and hide them in his hand.

Then you come up to him and tell him the number of matches he is hiding in his hand.

The secret is that after he has put the matches in his bag the second time, there are always nine matches in front of him. So you count how many matches are in front of him and nine minus that number will tell you how many matches he has in his hand.

## A TRICK WITH DICE

The fact that the sum of the numbers on the opposite sides of a die is always seven explains many unusual mathematical tricks with dice. Here is one of the best.

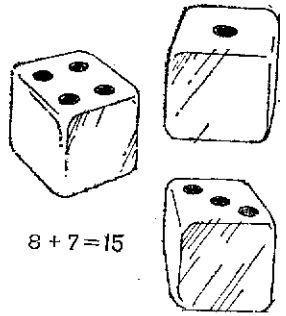
Turn round when somebody throws three dice. Ask him:

1) to add all the three numbers;



2) to take one die and add the number on the bottom face[1] to the number which he has already counted;

3) to throw the same die again and add again the number it shows on top.



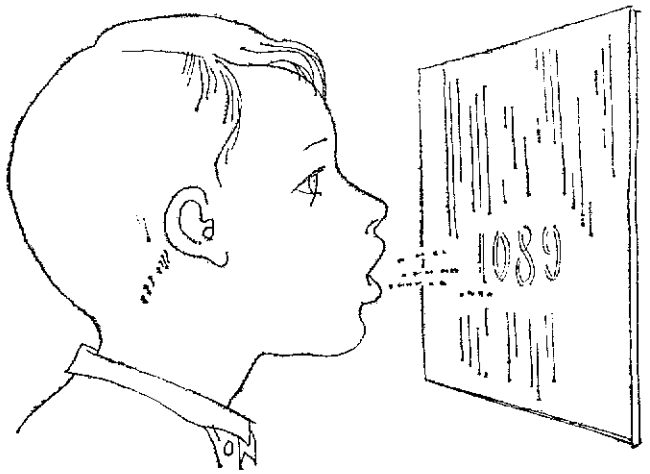

Now turn round and tell your friends that you can't know which of the three dice they threw again. Take all the dice, shake them in your hand a moment and then tell the correct sum.

How do you know? That is simple. You must add the numbers on the top faces[2] of the three dice before you take them in your hand, and add seven. If you think a little, you will understand why this works.

## THE WONDERFUL WINDOW

Ask your friend to write down any number of three figures in which the difference between the first and last figures is two or more than two. Imagine he has written *317*. Tell him to change the places of the first and the third figures. Then he

[1] **on the bottom face** — на нижней грани
[2] **on the top faces** — на верхних гранях



must subtract the smaller number from the larger (*713—317=396*). At last he must change the places of the figures in this answer and add them to the answer (*693+396=1089*).

"Now, if you breathe on the glass of that window," you say to him, "you will see the answer on the glass." When he breathes on the glass, he will see number *1089* on the window.

The secret is very simple: the answer is always *1089*. Before you do the trick, put some detergent[1] in a glass of water, then put your finger in the water and write with it *1089* on the window. Nobody can see the writing when it is dry, but when somebody breathes on the glass the place where your finger touched the glass will not become darker.

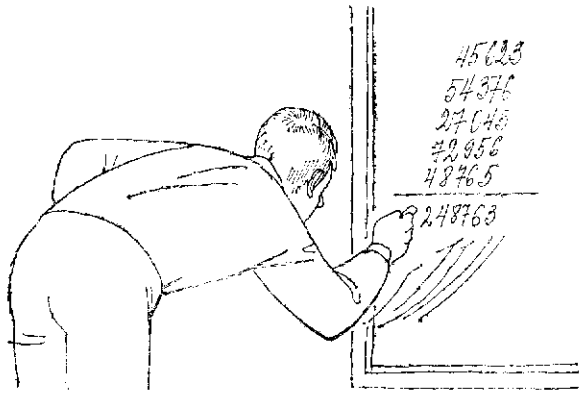
## QUICK ADDITION

Anybody can learn to count fast if he knows the secret of the following trick.

Ask your friend to write any five-figure number[2] on the blackboard. Then you write your five-figure number under it. You choose your figures so that each one with the figure above it will make nine.

For example: His number: *45 623*
Your number: *54 376*

[1] **detergent** — *эд.* мыльный (стиральный) порошок
[2] **five-figure number** — пятизначное число






Tell your friend to put a third five-figure number under your number. Then you write a fourth number in the same way. After he has written the fifth number, you draw a line under it and quickly write the sum. You may even write it from left to right!

How do you do it? You subtract two from the fifth number and put *2* in front of your answer. For example: if the fifth number is *48 765*, the sum will be *248 763*.

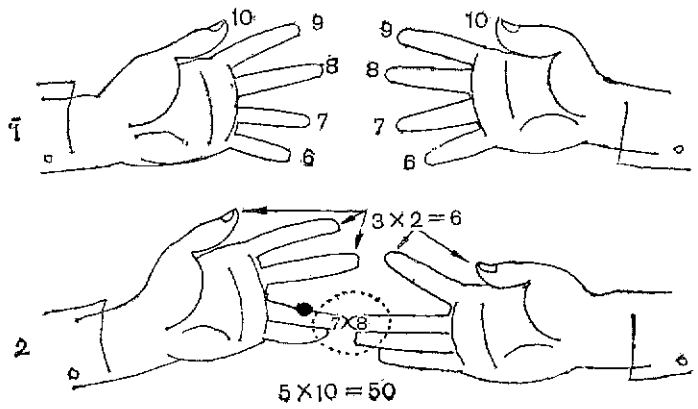
## AN INTERESTING WAY TO MULTIPLY NUMBERS

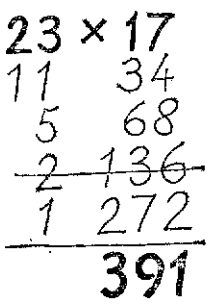
Here is an interesting way to multiply numbers from *6* to *10*. They used this method in some parts of old Russia before the Great October Socialist Revolution because at that time poor people and their children could not go to school.

If you want to try this method, you must do the following.

You give numbers to your fingers from *6* to *10*, as you see in Picture 1. If you want to multiply *7* by *8*, finger number *7* of one hand must touch finger number *8* on the other hand. Then the two fingers together with all the fingers under them are tens. You have five tens, that is *50*.

Then you multiply the number of the other fingers on the left hand by the number of the other fingers on your right hand. *3×2=6*. So *50+6=56*. This method always gives the right answer.






## STRANGE MATHEMATICS

There are many ways to multiply numbers of two or more figures. Here is one of the strangest.

Imagine you wish to multiply *23* by *17*. Half of *23* is *11*$^1/_2$. Write only *11* under *23* as you see in the picture. Half of 11 is *5*$^1/_2$. Write only *5*. Continue until you have *1*.

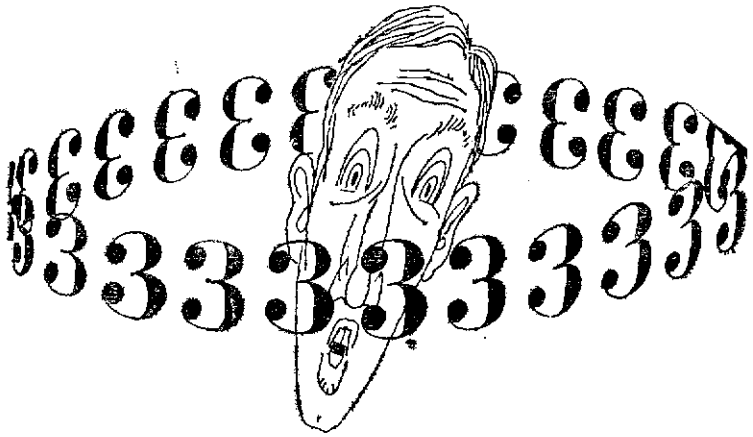
Now write numbers under *17*. But this time you must multiply each number by two to write the number under it. Continue until you have a number on the same line as *1*. Now draw a line through any row that has an even number on the left. In our example there is only one. Now add the rest of the numbers in the right-hand row.[1] Believe it or not, you will get the right answer. If you are interested why this method works, ask your teacher of mathematics to explain it to you.

## MAGIC IN MATHEMATICS

Here is an interesting trick you can show your friends. First take a sheet of paper and write on it the magic number *12 345 679*. It is easy to remember this number because there are all figures in it from *1* to *9*; only number *8* is not there.

Now ask a friend to tell you his favourite figure. Multiply the figure which he is going to tell you by *9* in your head. Write the answer under the magic number. For example, if he tells you that his favourite number is *3*, you write *27* under the magic number. Then ask him to multiply *12 345 679* by *27*. The answer will surprise him, because there will be only *3*'s in it—it is his favourite figure. The trick works with any figure. Try it and see.

[1] the right-hand row — правый ряд



## PSYCHOLOGY

### HOT OR COLD?

Many years ago when people had no thermometers, they usually touched a thing to see how hot or cold it was. The following experiment shows how easy it was to make a mistake.

Take three glasses: one glass with very hot water, another glass with very cold water, and the third glass with water at room temperature. Then you put a finger of one hand in the hot water, and a finger of the other hand in the cold water. You hold your fingers in the two glasses for a minute. Then you use each finger, one after another, to see how hot or cold the water in the third glass is. You will find that the water is warm to the finger that was in the cold water before, but the finger which was in the hot water before will feel cold in the same glass of water.

That is why you must always find the temperature in a scientific way. You must not try to tell the temperature as it seems to you.

You will often make a mistake if you take something that seems to you for a real fact. For example, when you are going to the circus by bus and you want to get there very quickly, it seems to you that your bus is going very slowly, slower than the other buses. But if it is Sunday and you have much free time, it seems to you that all the buses and cars are going very fast.

### "MOSCOW IN THE SPRING"

If you looked at this triangle and read the words as "Moscow in the spring", please look at it again.

The fact is that most people read a number of words at once; they do not read every word. That is why it is difficult for them to notice such mistakes like "the the" in the triangle.

You will have a very good time if you show this triangle to your friends. Some of them will read it four or five times before they notice the second "the".

### IT IS EASY TO REMEMBER SOME FACTS

Do you ever forget any important facts which you must remember? If you sometimes forget them, here are some examples which can teach you how to remember important facts and other things.

Which side of a ship or airplane has a door for people to come in or to come out when the ship or airplane is at the port? You can remember that it is the left side if you look in front, because "left" and "port" have the same number of letters.

Some teachers of mathematics in England remember $\pi$ to seven decimal places [1] because they remember the sentence, "May I have a large container of coffee?" The number of letters in each word stands for a figure of $\pi$.

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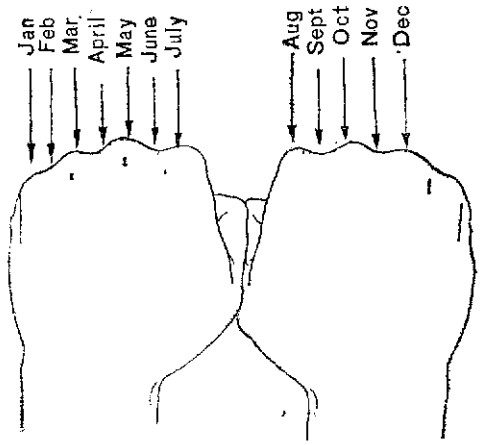
[1] **to seven decimal places** — до седьмого знака




The picture which you see shows how your hands can help you to remember the number of days in each month. You imagine the names of the months on your knuckles and the places between them (from left to right). All the months which are on the knuckles have 31 days; the others have 30 days, except February. February, as you know, has 28 days, but once every four years, that is in leap-years, it has 29 days.

## PHYSICS

### WATERMARKS[1]

Here is an interesting way to write a secret letter. You do it with the help of watermarks. If you collect stamps, you know what a watermark is. On every stamp there is a mark which you cannot see. You can see it only when you put the stamp in water. This mark is called a "watermark". The watermark proves that you have a real stamp. People make watermarks on stamps by applying pressure.[2] The places where they have applied pressure reflect light in a different way when they are wet.

It is easy to make watermarks and use them to write a secret letter. You put a sheet of paper in water, then take it out quickly and put it on a sheet of glass or a mirror. Put a dry sheet of paper on top of it. Now you may write on the dry sheet. You must use a hard pencil to apply pressure. When you raise the dry sheet you will find that you can see everything you have written on the wet sheet. When your wet paper becomes dry, you will not see anything, but the text will appear again if you put the sheet of paper in water and take it out quickly. Try it and see how it works!

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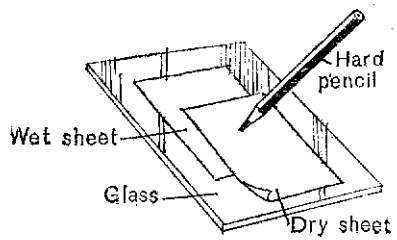
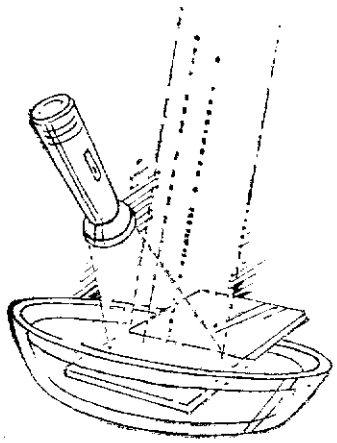
[1] **Watermarks** — Водяные знаки *(на бумаге)*
[2] **by applying pressure** — выдавливанием



## SPECTRUM ON THE CEILING



One of Newton's most famous experiments was to pass a beam of sunlight [1] through a prism to form rainbow colours [2] on the wall.

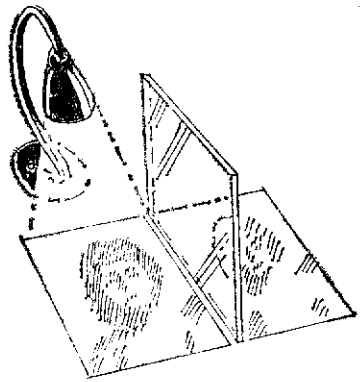
You can carry out an experiment of this sort with an electric torch, a mirror and a bowl of water.

Put the mirror in the bowl so that it is at an angle of 30° to the level of the water. When it is dark in the room, you shine your torch on the mirror. A small spectrum of colours will appear on the ceiling.

The experiment proves that there are many lights of different colours in white light. The water acts as a prism which reflects each colour at a different angle and forms different colours on the ceiling.

## A DEVICE TO COPY PICTURES [3]

You know that the glass of a window will reflect an image like a mirror. It will reflect an image especially well at night, when it is dark in the street and there is light in the room. Thanks to this fact you can make a very good device which you will use to copy pictures.



You get a sheet of glass and put it vertically on a table,

[1] **to pass a beam of sunlight** — пропустить луч солнечного света

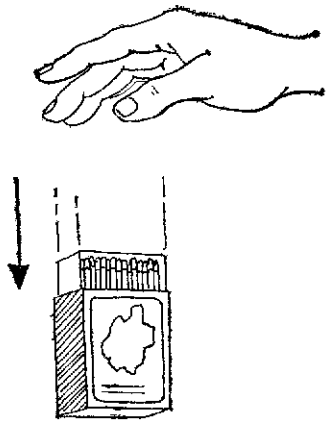
[2] **to form rainbow colours** — чтобы получить цвета радуги

[3] **A Device to Copy Pictures** — Приспособление для срисовывания картинок



as shown in the picture. Put the picture which you want to copy on one side of the glass and a sheet of white paper on the other side. Sit down on the side where the picture is. It must be dark in the room except for the lamp which shines on the picture. It will seem to you that there is an image of the picture on your sheet of white paper. Through the glass you will be able to see your hand and pencil when you copy the image.

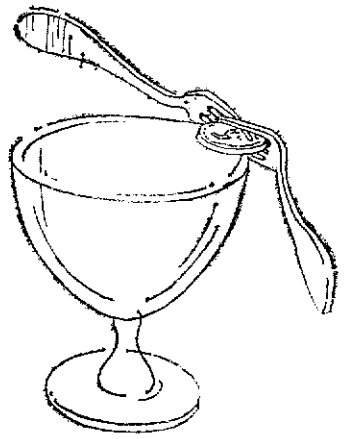
## AN EXPERIMENT WITH A BOX OF MATCHES



Ask somebody to hold a box of matches 30 centimetres over the table, then drop it so that it falls on one end and stands. When he tries it, the box will fall on its side.

You use the stabilizing power of friction.[1] Open the box of matches three centimetres as shown, then drop it. The box will stand, it will not fall on its side. There are many stabilizing devices which work on the same principle.

## THE FORKS WILL NOT FALL DOWN



Here is a simple and amusing experiment to demonstrate the force of gravity.[2]

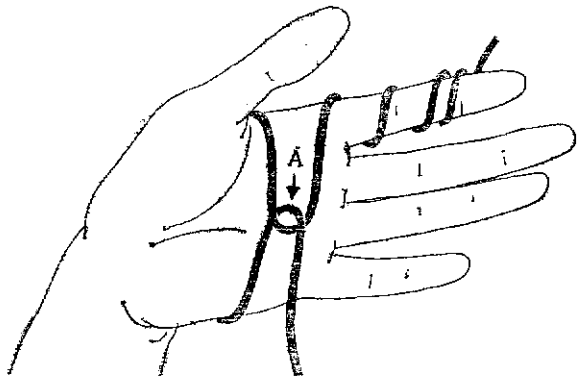
Take two forks and join their teeth tight together with the help of a five-kopek coin,

[1] **You use the stabilizing power of friction.**— Вы используете силу трения, которая придает коробочке устойчивость.

[2] **the force of gravity** — сила тяжести

as shown in the picture. Then put the coin with the forks on a rim of a glass. You will soon find the right position of the coin when you may let the forks go, and they will not fall down. The force of gravity will hold them on the rim.

## HOW TO BREAK A STRONG ROPE



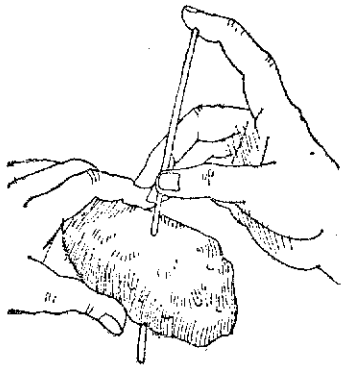

Do you know that there is a simple way to break a strong rope with your hands?

Tie one end of the rope round your left forefinger, then put it round the hand as shown. Now take the rope half a metre lower with your right hand and turn it 4 or 5 times round the right hand. Close your hands into fists. Hold the fists together, then quickly move your right fist down and your left fist up. The rope will break in your left fist at the point *A*.

This happens because all the force acts on the small point *A*. Here the rope acts like a knife and cuts through the point *A*.

## A LEMONADE-STRAW CAN GO THROUGH A POTATO[1]

You don't think it is possible, but it is. Hold an unpeeled potato and a straw as shown. Your finger must cover the top opening[2] of the straw. Strike the potato quickly with as much force as you can, but be sure the straw is perpendicular to the potato. After some practice you will be able to do it almost every time.



The explanation is this.

You are holding the potato in your hand; so it is in a state of rest.[1] It is inert. The straw which strikes the potato has a great impulse of force.[2] The pressure of the compressed air in the straw will keep it hard. That is why it goes through the potato.

[1] **A Lemonade-straw Can Go Through a Potato** — Соломинка для (питья) лимонада может проткнуть картофелину

[2] **the top opening** — отверстие верхнего конца



## EGG IN THE BOTTLE

If you want to demonstrate to your friends how strong the pressure of the air is, here is a simple way to do it. Take a hard-boiled egg[3] and a clean milk bottle. Take off the shell and put the egg on the opening of the bottle. Then ask your friends to push the egg into the bottle. At first they will think

[1] **in a state of rest** — в состоянии покоя

[2] **impulse of force** — импульс силы

[3] **a hard-boiled egg** — яйцо, сваренное вкрутую

it is possible. They will try and try, but they will not be able to do it. The egg will not go in because the air in the bottle cannot come out. The pressure of the air in the bottle will not allow the egg to go in.

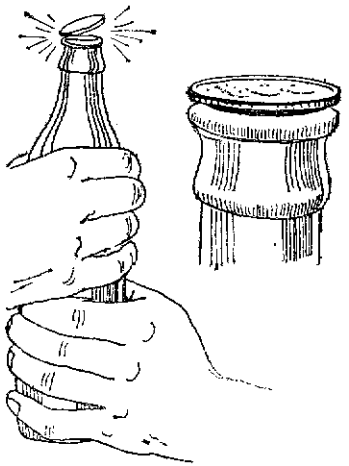
Then you show them how you can do it. You throw a burning match[1] into the bottle and put the egg on the opening. The fire uses up the oxygen in the bottle. Then the pressure of the outer air[2] on the egg pushes it into the bottle.

How do you take it out again?

After your friends have tried it many times, you turn the bottle down so that the egg falls nearer to the opening. Then put back your head, as shown in the picture, and blow as hard as you can[3] into the bottle which you hold upside-down. When you take your mouth away, the egg will come out so quickly that you must be ready to take it in your other hand. This happens because the pressure of the air in the bottle becomes greater than the pressure of the outer air.

## A THREE-KOPEK COIN CAN DANCE

The next time you buy a bottle of lemonade, you may try the following scientific experiment. When there is no lemonade in the bottle, but the bottle is still cold, you put a three-kopek coin on the opening, as shown in the picture. You must also put some two or three drops of water on the opening of the bottle.



Then you put your hands round the bottle and hold it for half a minute. The coin will begin to jump up and down in a strange way. After it has danced for some time, you take your hands away. The coin will continue to dance.

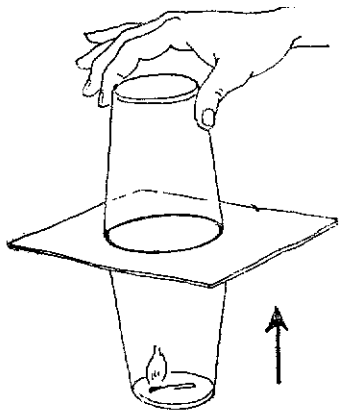
This experiment shows that things expand when you heat[1] them. And air too. When you hold the bottle in your hands, the cold air in the bottle becomes warmer. When the air becomes warmer, it comes out of the bottle and makes the coin dance.

[1] **a burning match** — горящая спичка

[2] **the outer air** — наружный воздух

[3] **as hard as you can** — как можно сильнее (изо всех сил)





## THE MAGDEBURG GLASSES[2]

You remember the famous experiment in Magdeburg, Germany, in 1650, when they proved how strong the force of vacuum was.

You can also prove it with the help of two glasses and a piece of wet blotting-paper. To do that you light some matches and put them into the lower glass. Put the wet blotting-paper on the brim, then quickly put the second glass on the paper as shown.

When the matches are burning, they will use up the oxygen in the two glasses. Now try to lift the upper glass. You'll find that the wet blotting-paper and the lower glass stick to it.

## BERNOULLI'S PRINCIPLE[3]

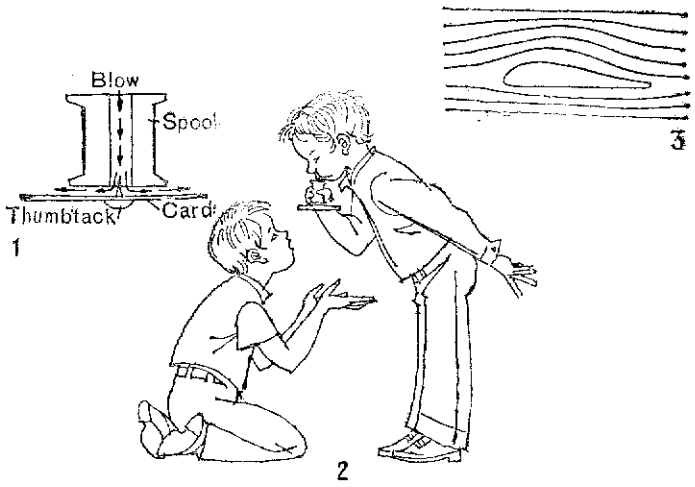
Bernoulli's principle says that when a gas or liquid is moving, its pressure becomes lower. When it moves faster, its pressure becomes still lower. Here is how you can demonstrate this principle at home.

You push a thumb-tack through the centre of a small piece of cardboard and put a spool over the thumb-tack, as shown in the picture. You hold the spool in one hand and the cardboard in the other. Then you raise the spool to your mouth and blow down through it as hard as you can. At the same time you let the piece of cardboard go. Do you think it will fall down on

[1] **expand when you heat** — расширяются при нагревании

[2] **The Magdeburg Glasses** — Магдебургские полушария (*или* тарелки)

[3] **Bernoulli's Principle** — Закон Бернулли *(давление текущей жидкости (или газа) больше в тех сечениях потока, в которых скорость движения меньше, и, наоборот: в тех сечениях, в которых скорость больше, давление меньше)*




the floor? No, it will not. It will stay at the other end of the spool when you are blowing.

Now that you know Bernoulli's principle, you can explain why your piece of cardboard doesn't fall down. When you are blowing into the spool, the air moves faster over the top of the cardboard and the air pressure[1] becomes lower. The air pressure under the cardboard is greater, and the cardboard does not fall down.

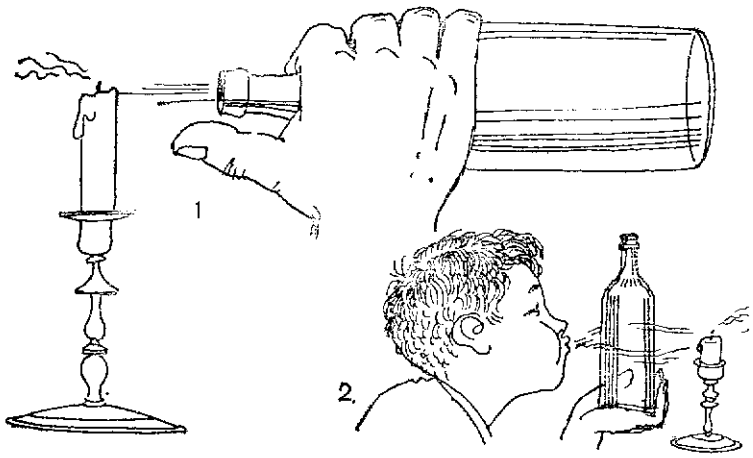
The same principle explains why an airplane does not fall down when it flies. They make its wings in such a way that the air moves over the tops of the wings faster than it moves under the wings. So the air pressure on the tops of the wings becomes lower than the pressure under the wings, and the airplane does not fall down. It flies. If it stops moving,[2] it will fall down.

### TWO INTERESTING WAYS TO BLOW OUT A CANDLE[3]

There are many interesting ways to blow out a candle and some of them are of scientific interest. Here are two ways to do that.

[1] **the air pressure** ['preʃə] — давление воздуха
[2] **If it stops moving** — Если движение прекратится
[3] **to blow out a candle** — задуть свечу





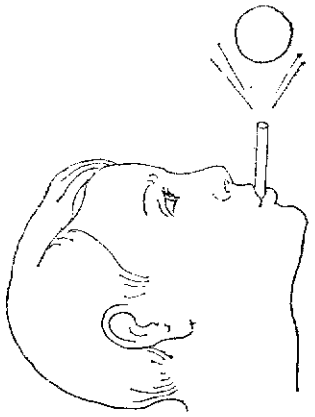

Take a clean bottle and close it with your thumb. Then put the opening of the bottle and your thumb into your mouth. Take away your thumb from the opening of the bottle and blow as hard as you can. Then close the opening of the bottle with your thumb again. Now if you put the opening of the bottle near the fire of the candle and take your thumb away, the compressed air which shoots out of the bottle[1] will blow out the candle.

Another interesting way to blow out a candle with the help of a bottle is to put the bottle between your mouth and the fire of the candle and blow (Picture 2). You will blow out the fire and your friends will think you were blowing right through the bottle.

The explanation is this.

The pressure of a gas becomes less and less the faster it moves. When you are blowing, the air moves past the bottle and forms a place with low pressure in front of the candle. The outer air comes quickly to this place and the whirling of the air[2] blows out the fire.

[1] **the compressed air which shoots out of the bottle** — сжатый воздух, который устремляется из бутылки
[2] **the whirling of the air** — вихревой поток воздуха



### AN EXPERIMENT WITH A TABLE-TENNIS BALL

Take a piece of lemonade-straw 15 centimetres long and put one end of it in your mouth. Lean back your head[1] and hold a table-tennis ball 6—8 centimetres over the other end. Blow as hard as you can and let the ball go[2] at the same time. The ball will not fall down as you thought. It will stay in the air. The harder you blow, the higher it goes above the straw.

The explanation is this.

We already know that when the air moves quickly, its pressure becomes lower. In this experiment the air which quickly comes out of the straw moves round the ball and forms a place with lower pressure over the ball. When you are blowing hard your ball stays in the air or goes higher above the straw. It cannot move in any other direction because the greater air pressure on the sides of the column of air which you are blowing makes the ball stay in the "column".

### COLD WATER CAN BOIL

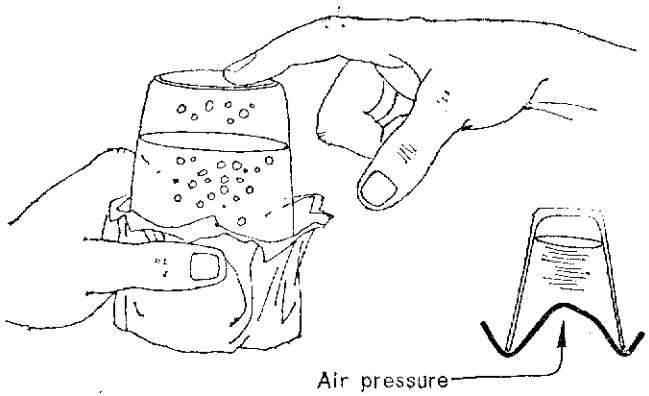
If you have been to the circus,[3] perhaps you have seen the following trick. The actor takes a glass of water and a wet handkerchief. He puts the handkerchief on the glass and pushes down the centre of the handkerchief. So the handkerchief on the glass looks like a well.[4] Then he turns the glass upside-down on his right hand, and takes it with his left hand, as shown in the picture. The pressure of the air pushes the handkerchief into the glass.

"When I put my finger on the glass," the actor says, "the water will boil." And he is right. When he does that, you see that the water is boiling. Some people say that they can even hear the noise of the water when it is boiling.

What happened was this.

[1] **Lean back your head** — Откиньте назад голову
[2] **let the ball go** — отпустите мячик
[3] **If you have been to the circus** — Если вы были в цирке
[4] **a well** — колодец



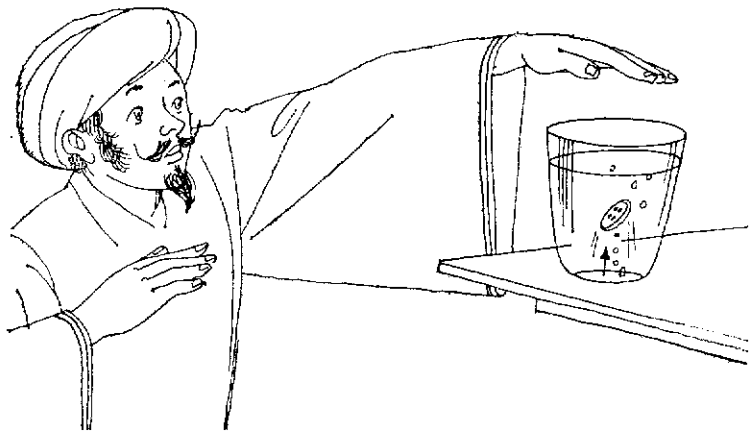



When the actor pushed the glass with his finger, the glass moved down a little through his left hand, and the handkerchief moved up a little. This lowered the centre of the handkerchief in the glass and made a vacuum. The vacuum made air come in through the handkerchief and you saw the illusion that the water was boiling.

### THE BUTTON WHICH DOES WHAT YOU TELL IT

You drop a button from a shirt into a glass of carbonated water.[1] The button goes down. A moment or two later you move your hand over the glass and say, "Button, come up." The

[1] **carbonated water** — газированная вода



button slowly moves up to the top. When you move your hand over the glass again and say, "Button, go down", it goes down again. This amusing trick works well with any small thing.

When it is resting on the bottom of the glass, little bubbles of carbon dioxide[1] begin to collect around it. When enough bubbles have collected to counteract the weight[2] of your thing, they raise it up. When it comes up, the bubbles disappear and the weight of the thing carries it down again. These movements up and down continue as long as there is carbonation[3] in the water.

You have, of course, tried it already and so you know how long you have to wait each time before you tell the button to go up or down.

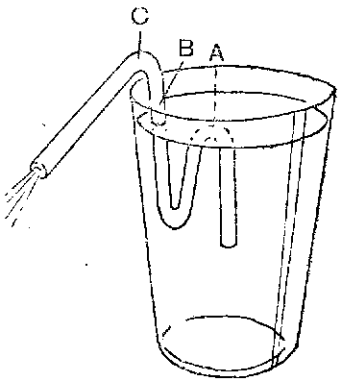
### AN AUTOMATIC SIPHON[4]

People have made many different automatic siphons, but this automatic siphon is so simple that you can make it from a glass tube.[5]

With the help of a candle you can bend the tube as shown in the picture. When your tube becomes cold again, you put it into the water, as you see, and your siphon will begin to work at once.

When point *A* on the tube goes down, the water (which always finds its own level) [6] runs through the tube to point *B*. Thanks to its inertia, the water goes up and over point *C* and begins to siphon.

You can also make such a siphon with the help of a plastic lemonade-straw. Water can run through such straws when you bend them. If one straw is not enough, you can put two or three of them together to make a long tube.




[1] **bubbles of carbon dioxide** — пузырьки углекислого газа

[2] **When enough bubbles have collected to counteract the weight** — Когда накопится достаточное количество пузырьков, чтобы противодействовать весу

[3] **carbonation** — выделение углекислого газа

[4] **An Automatic Siphon** — Автоматический сифон

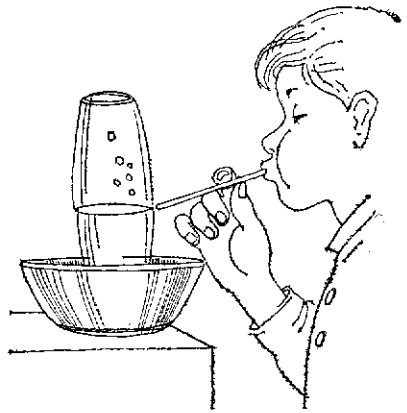
[5] **a glass tube** — стеклянная трубочка

[6] **the water (which always finds its own level)** — вода (которая стремится всегда восстановить первоначальный уровень)



### YOU CAN GET THE WATER OUT OF THE GLASS

Put two glasses of water one on the other, as shown in the picture. The lower glass is standing in a large bowl. You move the upper glass a little to make a very small opening between the two glasses. The air pressure will not allow the water to come out.



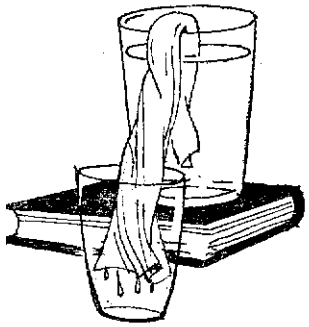
Now ask your friend if he can get the water out of the upper glass, but he must not touch the two glasses in any way. You may be sure he will not be able to do it.

It is possible to do it with a straw. You hold one end near the opening between the two glasses and blow through the other end as hard as you can. Air will come up into the upper glass and make the water come out through the opening and down into the bowl.

(If you find it difficult to put the two glasses of water one on the other, put them underwater in a large bowl, hold them together and then take them out.)

### THE WATER IS IN THE LOWER GLASS

Take a wet handkerchief, turn one end of it but hold the other end. Then you put it over two glasses, as shown in the picture. You must be sure that the handkerchief touches the lowest part of the higher glass but only the top of the other



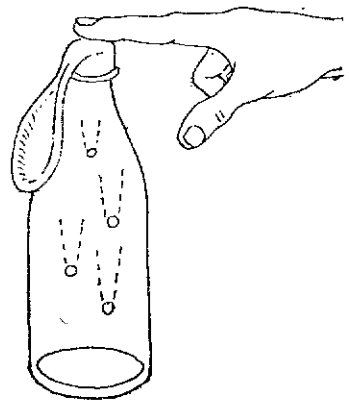
glass. At night before you go to bed, you fill the higher glass with water. The next morning you find all the water in the lower glass!

This phenomenon is called capillary action.[1] It made the water which was in the higher glass go through the handkerchief to the lower glass. You will learn more about it in the ninth form.

## PASCAL'S LAW[2]

Pascal's law tells us that if you apply pressure to a confined gas or liquid,[3] the gas or liquid transmits the pressure undiminished[4] in all directions and the pressure acts on all parts of the liquid.

You can demonstrate this with the help of a lemonade bottle, some matches and a balloon. You cut off the heads of the matches and then drop the heads into the bottle. Then you fill the bottle up to the opening with water and tie the mouth of the balloon tightly over the opening. The heads of the matches will be on top of the water, but when you press your finger on the balloon (as shown in the picture), they will go down slowly to the bottom. When you raise your finger, the heads go up again.



The explanation is this. The pressure, which you transmit through the water, makes a very small part of water get into each head of the match. Then the head of the match becomes heavier and goes down. When you raise your finger, there is enough air pressure in the heads to make the water come out of them. So the match heads go up again.

[1] **capillary action** — капиллярное движение *(жидкости)*

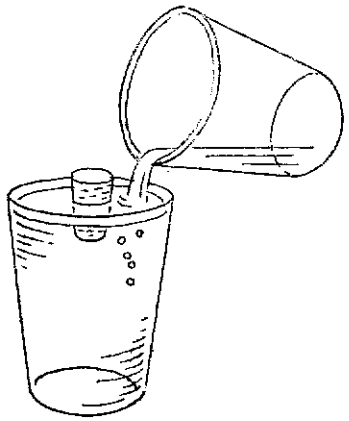
[2] **Pascal's Law** — Закон Паскаля

[3] **if you apply pressure to a confined gas or liquid** — если вы производите давление на газ или жидкость, содержащиеся в замкнутом сосуде

[4] **transmits the pressure undiminished** — передает давление без изменения



## PUT THE CORK IN THE CENTRE



Fill a drinking glass with enough water so that it is almost full. Put a small cork into the glass and ask your classmates or friends to make the cork stay in the centre of the water; it must not touch the sides of the glass. They will not be able to do it. The cork always moves to one side.

When your friends have decided that it is impossible, you show them that it is easy to do it. Add more water to the glass from another glass until the water is a little over the rim. Be very careful. Because of the surface tension,[1] the water will form a convex surface.[2] The cork moves to the centre, where the water is highest, and there it will stay.

## AN EXPERIMENT WITH A CARDBOARD ARROW[3]

Everybody knows that most things expand when you heat them and contract when you cool them.[4] But do you or your friends know what contracts when you heat it? It is rubber. You can demonstrate that rubber contracts when you heat it by the following experiment.

Take a rubber band[5] and put it round a small box. Then you cut out a cardboard arrow, put it on a pin, and push the pin under the band, as shown in the picture. If you now bring

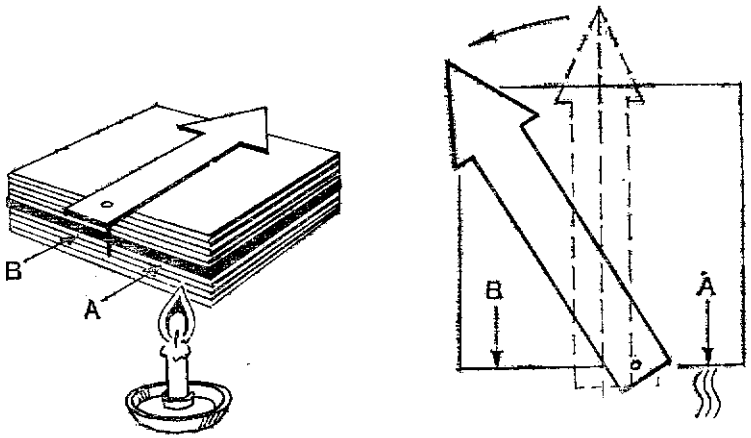
[1] **Because of the surface** ['sɔ:fɪs] **tension** ['tenʃn] — Благодаря поверхностному натяжению

[2] **a convex** ['kɔn'veks] **surface** — выпуклая поверхность

[3] **a cardboard arrow** — стрелка из картона

[4] **contract when you cool them** — сжимаются при охлаждении

[5] **a rubber band** — круглая резинка *(для упаковки лекарств и т. п.)*




a candle to the point *A* of the rubber band, the cardboard arrow will move slowly to the left. If you move the candle near the point *B* of the rubber band, your arrow will slowly move to the right.

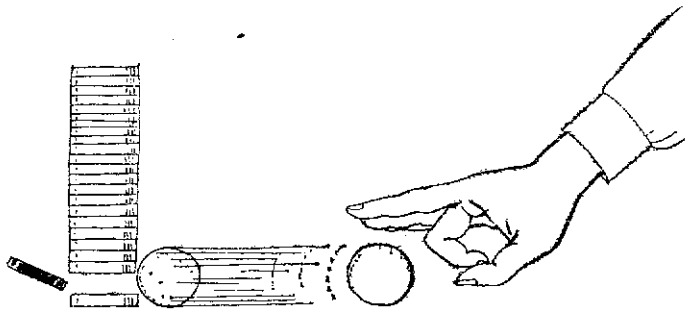
Now you can explain it.

The heat makes the rubber band contract. When it contracts it turns the pin and the arrow moves to the left or to the right.

## HOW YOU CAN DEMONSTRATE INERTIA

You know, you can demonstrate inertia with the help of checkers.

You build a tower of white checkers; only the second checker from the table (or floor) is black. Thirty centimetres





away you put another checker vertically, as shown in the picture. If you press your finger down on the side of this checker,[1] it will move quickly to the tower. When the checker comes up to the tower, it will push out the black checker, but all the other checkers will not fall down.

This simple experiment demonstrates inertia. Thanks to inertia the white checkers do not fall down when the black checker comes out.

(If your checkers are small, you may find that it is better to put the black checker third from the table instead of second.)

## THE EGG AND FRICTION

Imagine somebody has given you a number of eggs on a plate and said, "One of these eggs is hard-boiled. The rest are raw. Can you find the hard-boiled egg if you don't break any of them?"

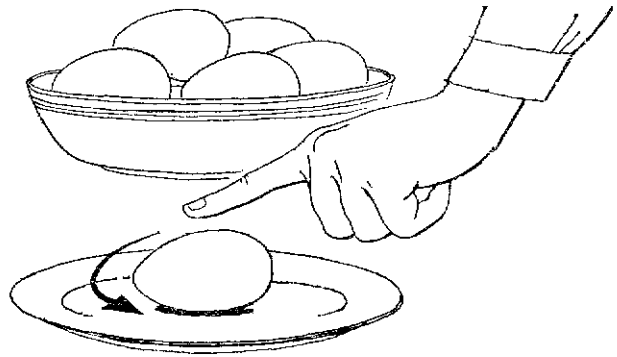
You will be able to do that if you know the laws of friction.[2] Put only one egg on the plate and try to spin it. The only egg that will spin well is the hard-boiled egg. The raw egg will not spin well because the friction between the layers of its liquid and the friction between the liquid and the shell kill the spin.[3]

---

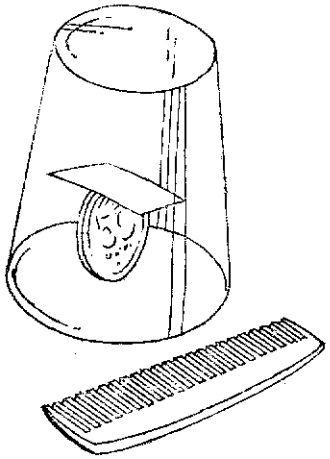
[1] **press your finger down on the side of this checker** — щелкните пальцем по этой шашке

[2] **the laws of friction** — законы трения

[3] **kill the spin** — замедляют вращение



Put a fifty-kopek coin on its side, then put a small piece of paper on it and cover them with a drinking glass, as shown in the picture. Now ask your friend to throw the piece of paper off the coin, but he mustn't touch the glass or jump on the floor. The coin must not fall down.



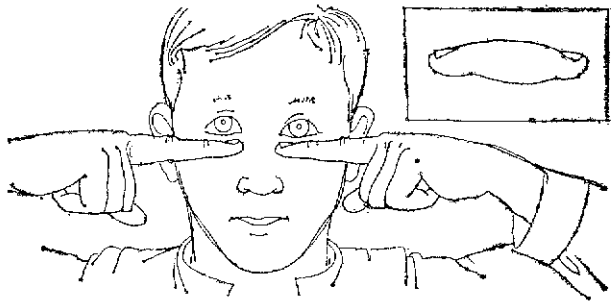
Don't show him at once how to do it. Let him think and try it for a long time. When at last he says it is impossible to do it, you comb your hair (the hair must be dry), and then put the comb (as if by chance) near the side of the glass. The piece of paper will fall down at once. But there is no magic. It is electricity that makes the piece of paper fall down.[1]

[1] **It is electricity that makes the piece of paper fall down.**— Под действием электричества лист бумаги падает.

## OPTICAL ILLUSIONS

### A FUNNY FINGER

Do you want to see an interesting optical illusion? If you do, put your two forefingers together and hold them 7 or 8 centimetres in front of your eyes, as shown in the picture. Look over the fingers and focus your eyes on something far



away. Now hold your fingers a centimetre away from each other and look between them. You will see a funny finger in the air with a nail at each end!

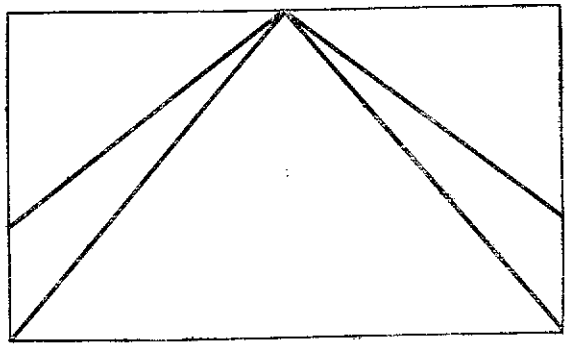
This is what happens.

When you hold your two fingers in front of your eyes, the picture of your left finger in your left eye and the picture of your right finger in your right eye come together in part[1] and you see a funny finger with a nail at each end.

### CIRCLES ON THE CARD

Draw four thick lines on a piece of cardboard, as shown in the picture. Push a pin through the centre. Then hold the

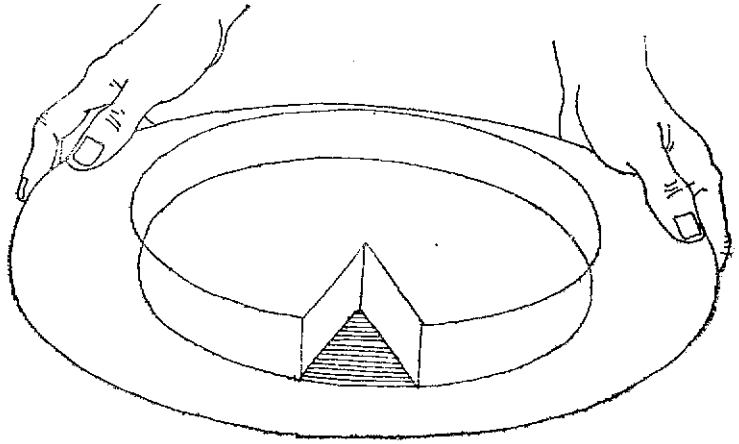
[1] **come together in part** — частично сливаются



pin and spin the piece of cardboard. To your surprise, you will see two concentric circles. The trick works with two lines, but the illusion is stronger if there are four.

### A MISSING PIECE OF CAKE

Where is the missing piece of cake?
You will find it if you turn the picture upside-down.[1]

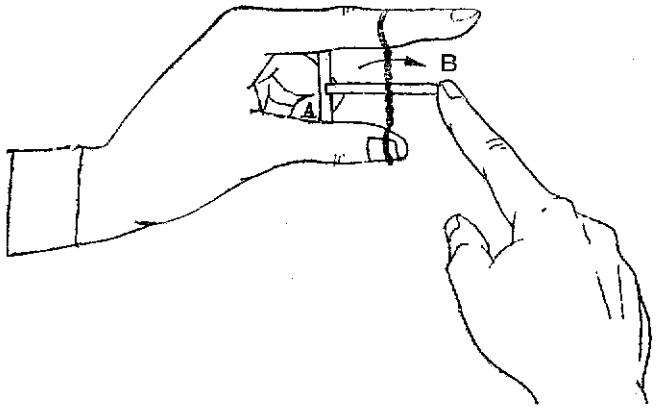


### AN OPTICAL ILLUSION WITH A MATCH

If you want to see this interesting optical illusion, you must take two matches and a small rubber band. The matches must have no heads. Put the rubber band on two of the fingers

[1] **upside-down** — вверх ногами






of your left hand, as shown in the picture. Put one of the matches through the rubber band and turn it many times from end *A* to end *B*. Then you put the other match between the two fingers of your left hand and the first match will not turn back. With your right finger you move match end *A* to the right. This will bring end *B* against the other side of the second match.

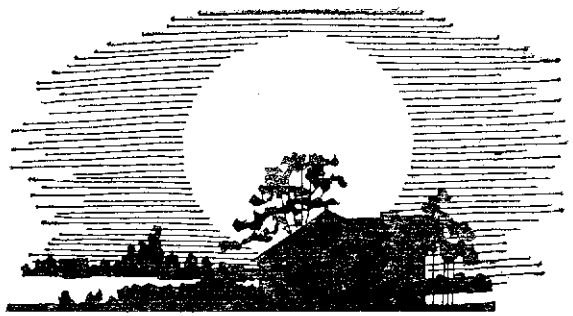
Now you are going to demonstrate the illusion. Tell your friends that you can make the first match go through the second match. You raise your right finger for a moment. During this moment end *B* comes back to your right finger. This movement will be so quick that your friends will not notice it. After some practice you will be able to do it so well that your friends will not notice the movement of your right finger too. The illusion will make them think[1] that one match has gone through the other match.

### MOON ILLUSION

One of the most interesting of all natural illusions is the large size of a full moon when we see it low on the horizon.[2] Six hours later, when the moon is high in the sky, we think

[1] **The illusion will make them think** — Вследствие иллюзии они будут думать

[2] **low on the horizon** [hə'raɪzn] — у самого горизонта

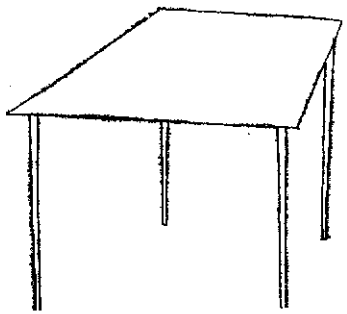


that it has become much smaller. But photographs show that the diameter of the moon when it is high in the sky is the same as when it is low on the horizon. We shall see the same illusion if we go to a planetarium.

Scientists do not agree on why this happens. Some of them think that the moon on the horizon looks larger because we can see it together with some trees or houses (which are on the horizon too). But this does not explain why the illusion is the same at sea, where there is nothing on the horizon.

Now some scientists think that this illusion takes place because things look smaller when we must raise our eyes to see them.

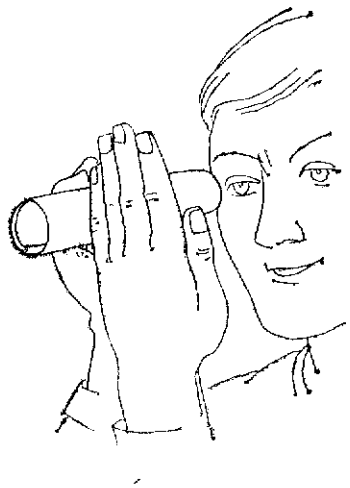
## AN ILLUSION WITH A THREE-KOPEK COIN



Can you put a three-kopek coin on this picture of a table so that the coin does not touch the sides of the table? At first you will think it is possible, but when you try to do it, you will find that the coin is very large. You thought that it was smaller. It was an illusion. The angles of the picture help to cause the illusion.[1]

[1] **The angles of the picture help to cause the illusion.** — Углы картинки помогают создать иллюзию.





## YOU CAN SEE THROUGH YOUR HAND

If you want to see through your hand, you must take a sheet of paper and make a tube. With your right hand you put one end of the tube to your right eye, as you do it with a telescope. Then you hold your left hand at the tube, as shown in the picture. You focus your eyes on the wall of the room. It will seem to you that you are looking through a hole in your left hand. If you move your hand, you can find a place where it will seem to you that the hole is in the centre of your hand.

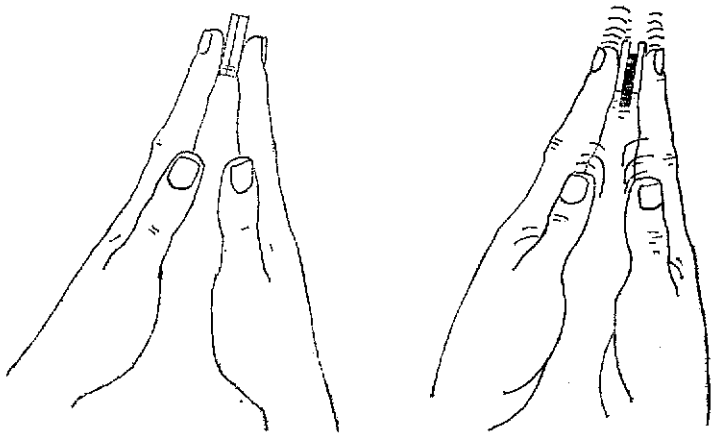
It is binocular vision[1] that explains this illusion. The picture of the hand in your left eye runs over the picture which you see with your right eye.

If you move one of your hands away from the other, you will see that the hole is moving away from the centre of your left hand. Then you move the hand back, and the hole moves back to the centre of the left hand.

## THE THIRD COIN

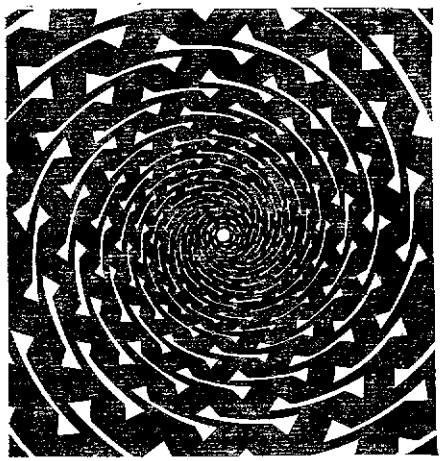
It is easy to show an interesting optical illusion with two coins. Hold the coins between your forefingers as you see in the picture. Rub the coins against each other. A third coin will appear between and below the other two. This is because your eyes keep the images of the two coins in their lowest positions. But nobody can explain well enough why the third coin always appears below and never above the real coins. (See the picture on page 60.)

[1] **binocular vision** — бинокулярное зрение *(зрение двумя глазами, при котором создается объемное восприятие предметов)*



## A STRANGE SPIRAL

You are sure that this picture shows a spiral line that begins from the centre. But if you try to follow the line with a pencil, you will find that it is not a spiral. You have a number of concentric circles. You may show this optical illusion to your friends if you twist together a black and a white piece



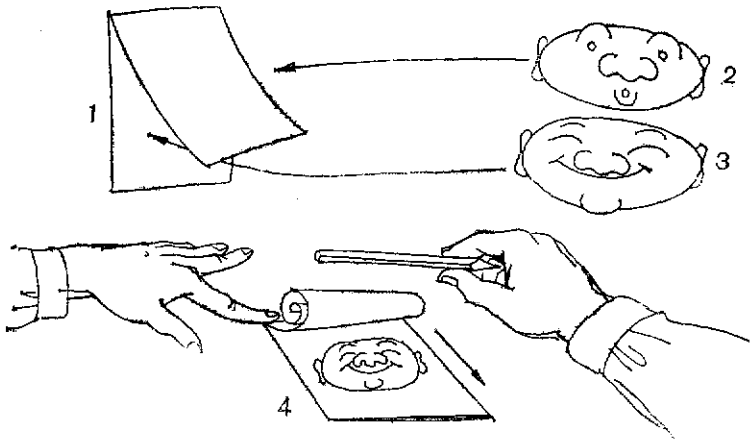


of rope to make one rope and put it on a carpet which has different pictures on it. Scientists give different explanations of this optical illusion. They don't agree on one explanation.

## PAPER FILMS

You may show how cinema films run with the help of this paper toy.

Fold in half a piece of paper $7^1/_2$ by 20 centimetres (Picture 1). On the lower leaf draw the face shown in Picture 2. On




the upper leaf draw the face in Picture 3. Turn the upper leaf into a tube[1] (Picture 4).

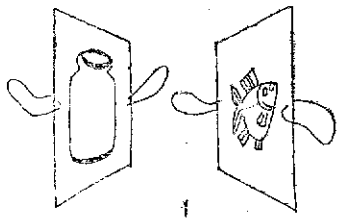
Your left finger holds the upper left corner and your right hand holds a pencil above the upper leaf, as shown. Move the pencil up and down quickly. The upper leaf will unroll and roll up again,[2] and you will see a short but funny film.

---

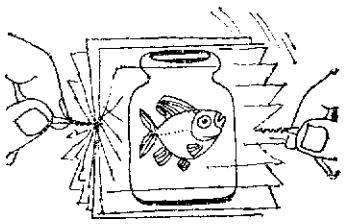
[1] **Turn the upper leaf into a tube** — Сверните верхний листок в трубочку

[2] **will unroll and roll up again** — будет раскручиваться и снова закручиваться

## A TURNING DEVICE[1]



1



2

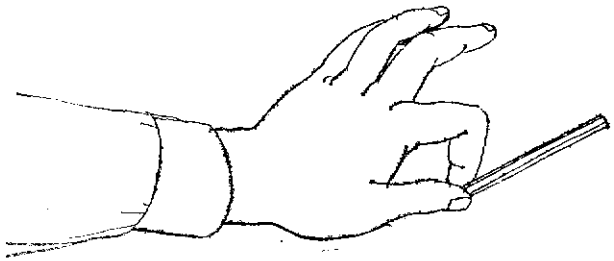
This turning device will show you that your eye can keep a picture of a thing for half a second after you have put that thing away. You can make a turning device in the following way.

Cut out a square piece of cardboard 4 by 4 centimetres. Make two holes and tie short pieces of string, as shown in Picture 1.

Draw a large fishbowl on one side of the square and a small fish on the other side. Hold the pieces of string between your fingers. Now you can turn the square very quickly with your fingers. When it is turning, you will see only one picture of the fish inside the bowl (Picture 2).

## AN ILLUSION WITH A PENCIL

You can make an interesting illusion with the help of a pencil. Take a pencil and hold it with your fingers near one end, as shown in the picture. Then you move your hand up and down no more than five centimetres. You must try not to move the pencil a little with your fingers. You hold it in an easy way so that it moves as your hand goes up and down. If you do it the right way, it will seem to you that you are holding a rubber pencil which bends all the time.

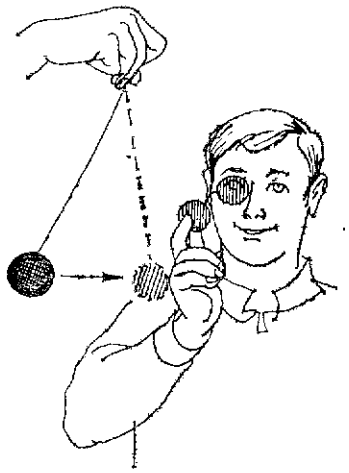


[1] **A Turning Device** — Вертушка



## A PENDULUM WHICH MOVES IN A CIRCLE[1]

You can demonstrate this interesting optical illusion if you get a pendulum and dark eye-glasses. It is easy to make a pendulum. You tie a small thing to one end of a rope 60 centimetres long and your pendulum is ready. Then you ask your friend to stand at the other end of the room and move the pendulum there and back in front of your eyes.

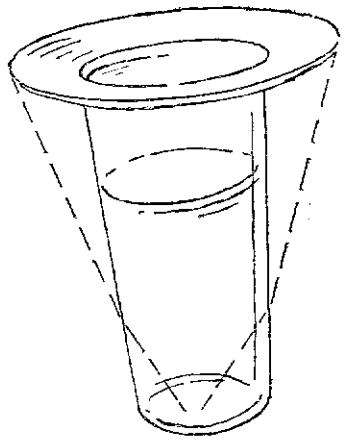


You hold the glasses so that only your right eye is looking through a dark glass. But your left eye must be open too. Then it seems to you that the pendulum is moving in a circle!

Now hold your eye-glasses so that only your left eye is looking through the dark glass. Your right eye is open too. It seems to you that the pendulum is moving in a circle again, but in a different direction.

Scientists explain this optical illusion in different ways. Some time ago one of the scientists explained it in the following way: the images of the pendulum get to your brain through the eye with the dark glass and through the other eye, on which there is no glass. But the images which come through the eye with the dark glass get to the brain a moment later than the images which come through the other eye, on which there is no glass. But some scientists say that this does not explain why it seems to us that the pendulum moves in a circle.

[1] **A Pendulum** ['pendjuləm] **Which Moves in a Circle** — Маятник, который ходит по кругу



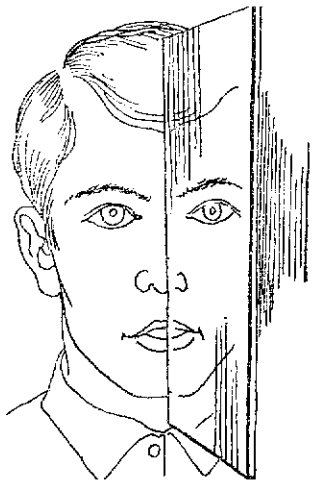
## THE STAMP WHICH DISAPPEARS

Put a stamp on your table. Then put a glass of water on the stamp. Cover the glass with a saucer, as shown. The stamp disappears! Walk around the glass and look into it from different sides. You will not be able to see the stamp.

The explanation lies in the phenomenon of refraction.[1] The rays of light bend[2] when they pass at an angle from water to air. The lines show the refraction. There is no angle from which you can see the stamp.

## THE TWO SIDES OF YOUR FACE ARE DIFFERENT

Do you think that the right side and the left side of your friend's face look the same? If you think they look the same, get his photograph and take a small mirror. (It is better to take a mirror without a frame.) Then you put one side of the mirror on the centre of the face, as shown in the picture. You will see the whole face of two left sides of the photograph. If you want, you may turn the mirror the other way and then you will see the whole face of two right sides of the photo.



Many years ago some people thought that the two sides of a face could be different. For example, one side of the face may look happy and the other side unhappy. Today we know it is not true, but still the experiment is very interesting because it proves that the two sides of a face are not the same. You may try it on your own picture. The experiment will surprise you. You will see how different your "two" faces are.

[1] **the phenomenon of refraction** — *эд.* явление, которое называется преломлением лучей

[2] **The rays of light bend** — Лучи света преломляются



## YOU HAVEN'T SEEN THE REAL IMAGE OF YOUR FACE IN THE MIRROR

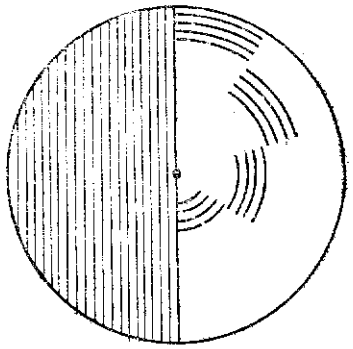
You have often looked into a mirror, of course. But you haven't seen the real image of your face yet. And this is why you couldn't see it.

When you look into a mirror, you don't see your face as other people see it. You see a reversed image. If you close your left eye, your image closes its right eye. If you touch your right ear with your right hand, your image touches its left ear with its left hand.

If you have two small mirrors, you can see your face as your friends see it. You hold the two mirrors at right angles to each other[1] and look into them, as shown in the picture. After some practice you will be able to see the real image of your face.

Now close your left eye and your image closes its left eye too. Touch your right ear with your right hand and your image touches its right ear with its right hand! This happens because each mirror reflects the image in the other mirror. So you see a reversed image of a reversed image, which, of course, is the same as the real image.

[1] **at right angles to each other** — под прямым углом друг к другу

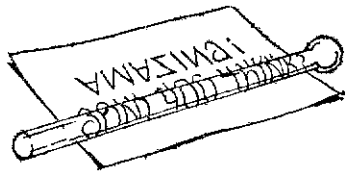


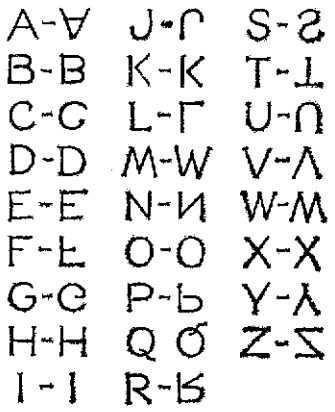
## COLOUR THAT ISN'T THERE

To show this interesting phenomenon which scientists call "subjective colour"[1] copy the circle which you see in the picture and put it on cardboard. Push a pin through the centre and turn it quickly. You will see many circles of different colours! Now change the direction and the order of colours will also change.

A few years ago a television operator turned a large wheel of this sort, and people who were watching his programme saw the colours quite clearly on their black-and-white television screens.[2]

Scientists haven't yet agreed on what makes these colours appear.





## YOU CAN READ A SECRET LETTER FROM YOUR FRIEND

If you want to understand this secret letter which you have received from your friend, you must use a cylindrical glass stick.[3] You hold the stick over the words of the letter near the page and read the letter through the glass stick.

The glass stick shows you a reversed image of each letter. At the same time it helps you to see each letter right side up

[1] **"subjective colour"** — субъективно воспринимаемый цвет

[2] **black-and-white television screen** — черно-белый телевизионный экран

[3] **a cylindrical glass stick** — цилиндрическая стеклянная палочка

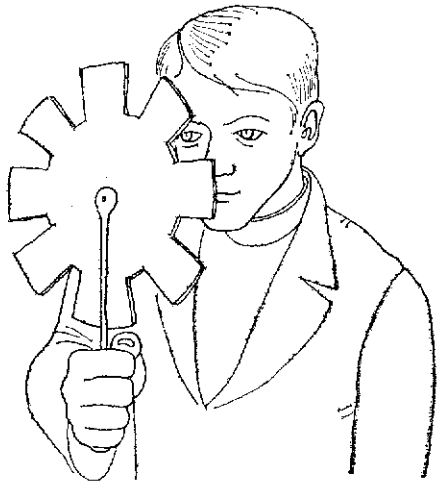


when your friend wrote it upside-down. So your friend and you must use the reversed letters which you see in the picture.

## YOU CAN MAKE A STROBOSCOPE[1]

A stroboscope is a device which cuts off light for a moment, then for another moment and so on[2] many times. When you look through it at a thing which is moving, it seems to you that it is moving slower or that it stops.

You can easily make a stroboscope if you cut eight long holes in a round piece of cardboard. Then you put a pin through



the centre of your cardboard circle and push the pin into a small stick or pencil so that you can turn the cardboard in front of one eye, as shown in the picture.

Now look through the stroboscope at a thing when it is moving. The thing may be an electric fan or even your stroboscope when you see it in the mirror. You make the stroboscope turn faster and slower. It will seem to you that the thing

[1] **a stroboscope** — стробоскоп *(Это оптический прибор, при помощи которого можно видеть предмет, совершающий какое-либо движение, неподвижным или движущимся замедленно.)*

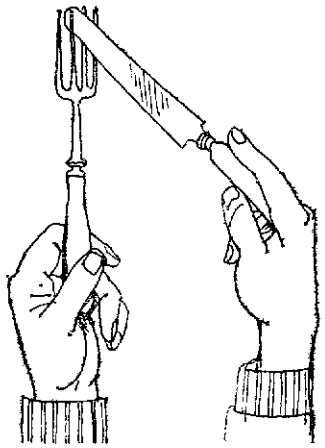
[2] **and so on** — и так далее

at which you are looking has stopped moving, or that it is moving slowly in the same direction, or that it is moving slowly in the other direction. This is because you see the thing only from moment to moment. Between these moments you do not see how it moves.

At the cinema you often see illusions of this sort. It happens because the camera takes pictures of things when they are moving in the same way, that is from moment to moment.

## EXPERIMENTS WITH SOUND

### A MUSICAL FORK



If you pick one of the teeth of a fork[1] with a knife, as shown, you will hear nothing. But if you press at once the end of the fork against a table, you will hear a musical noise.

You may show this trick to your friends after dinner. But you must practise it first. You must pick one of the teeth of the fork, then hold the knife over an empty drinking glass. When the knife is over the glass, you move your other hand so that the end of the fork touches the table. Your friends must not notice it. They will look at the knife and think that the noise is coming from the glass. But when they try the trick, it won't work, because the noise comes from the table. Scientists call the noise "sympathetic vibration".[2]

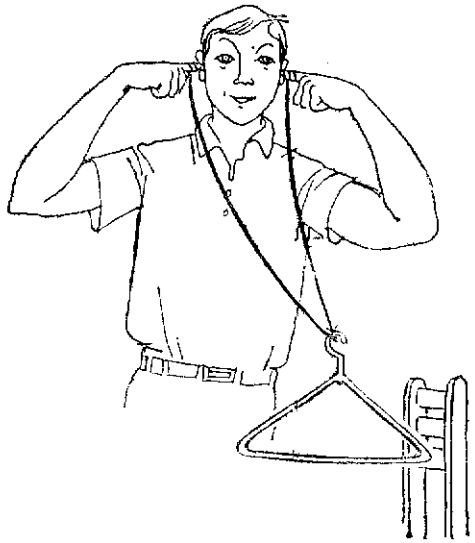
### MUSIC FROM A COAT-HANGER[3]

Do you know that you can hear musical noises from a coat-hanger?

If you want to hear them, you must tie a metal coat-hanger to the centre of a piece of rope a metre and a half long, as shown in the picture. Now you understand what you must do

---

[1] **pick one of the teeth of a fork** — заденете один из зубьев вилки
[2] **"sympathetic vibration"** — ответная вибрация
[3] **Music from a Coat-hanger** — Музыку создает вешалка *(для платья)*



next. You tie one end of the rope three or four times round your left finger, then the other end the same way round your right finger, and put the ends of your fingers into your ears.

Now you come up to a chair and allow the coat-hanger to strike against it. You will hear with surprise some beautiful music, like the music of a large bell or of an old clock.

You hear the music because the coat-hanger vibrates. The rope and your fingers bring the sound waves[1] to your ears.

### A MUSICAL GLASS OF WATER

Ask your friend if he can use a glass of water as a musical instrument. Of course, he can't.

Then you take a glass of water. (Thin glasses work best.)

[1] **the sound waves** — звуковые волны



You put your finger in the water and then move it slowly round the rim of the glass, as shown in the picture. Your finger must not be very wet, but it must not be dry. So you must try many times. At last you will hear clear music which comes from the glass.

When your finger moves round the rim, it makes the glass vibrate and the glass makes a musical noise. The same principle makes the violin and its strings give music.

The American scientist Benjamin Franklin made a musical instrument out of glass bowls. He used the same principle. He called his musical instrument an "armonica".